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SATURDAY, JANUARY 14, 1882.

We refer our readers to another column of this issue where a letter written by Professor George S. Morris, A. M., of the University of Michigan, and Lecturer in the Johns Hopkins University, may be found. This letter is a reply to an editorial in the *Popular Science Monthly* for January of this year, which repudiates the assertion that Herbert Spencer is an atheist, or that his writings have an atheistical tendency, the writer claiming for Spencer that the world is under an obligation to him for elevating man's conceptions of the character of the Deity, and that Spencer, so far from being an atheist, has contributed new and powerful arguments for the existence of an "Infinite and Eternal Spirit," and further that Spencer is ever bringing us to the underlying truth and therefore doing the highest religious work.

As a masterpiece of special pleading the article in the *Popular Science Monthly* to which we refer, will be read with interest, and if it were possible to reason or talk an Augean stable into cleanliness, the editor of the *Popular Science Monthly* might have succeeded in the task he had in hand. Professor Morris has torn off the hypocritical mask of divinity assumed by the editor of the *Popular Science Monthly* for Herbert Spencer, and exposed the real nature of his teachings. Had the editor of the *Popular Science Monthly* merely claimed some mitigating circumstances, or some underlying truths in Spencer's teachings which merited recognition, he might have succeeded in deceiving his readers, who he evidently believes are at the mercy of his sophistry, but to claim for Spencer, the position of a great religious teacher was proving too much, and gives a ludicrous aspect to the whole discussion. As Shakespeare says:

> 'Tis too much prov'd,—that with devotion's visage
> And pious action, we do sugar o'er
> The devil himself.

Let us calmly examine what Herbert Spencer really teaches, and to those who desire to follow us, and have no time to wade through Spencer's voluminous works, we advise a perusal of Professor Morris's valuable work, "British Thought and Thinkers," published by S. C. Griggs & Co. of Chicago. We will now make a few quotations from this work, and as the author is a teacher of this subject in two of the leading Universities in the United States, he may be acceptable as an authority sufficient for our purpose.

What is the "Infinite and Eternal Spirit" which Spencer would have us accept as God? Spencer merely terms it "*the unknowable*," a something or a nothing, which "is absolutely beyond our knowledge." Whatever it may be "it does not come within the range of sensitive consciousness." In plain English this "*unknowable*" may be a God, a Devil, or it may be an ether, electricity or anything else. One thing is certain, that it is not spiritual and is devoid of intelligence.

All that relates to mind or matter is purely mechanical in Mr. Spencer's estimation. He contemplates man in common with the whole universe as the subject and scene only of purely mechanical, automatic, irresponsible and unreasoning processes, in fact the whole knowable universe is brought under the one category of mechanism.

Man is simply "sensitive flesh and blood alone," his very individuality denied, for Spencer says that "the reality of a belief in *self* admits of no justification." *Mind* is a mere bundle of phenomena of a mechanical nature, and *consciousness* simply "molecular oscillations and the transmission of motion in the nervous system," and as if to strike from man the last vestige of his humanity, *morality* is annihilated, for *good and evil* are measured by the amount of pleasure or pain which results. Thus the perfect man, like the perfect hog, is the one whose nervous organization is perfectly adapted to surrounding physical conditions, the man and the brute on one level, soulless and devoid of any spiritual nature.

Such is the Spencerian theology. Readers, picture to yourselves such a God, and man as we have described, and then knowing the real nature of his teachings, imagine Herbert Spencer elevated to the rank of a spiritual teacher who "is ever bringing us near to the underlying truth, and therefore doing the highest religious work," and the sickening hypocrisy of this whole business is apparent.

Well did the rugged philosopher Carlyle exclaim, "There is but one thing without honor; smitten with eternal barrenness; inability to do or be: Insincerity, Unbelief. He who believes *nothing*, who believes only the show of things, is not in relation with Nature and Fact at all."

Much more could and perhaps should be said on

this subject, but as we cannot spare eleven columns to editorial remarks, we will conclude by stating that a wrong is inflicted upon Science by those who suppose it is answerable for Mr. Spencer's debased views of God and man. In summing up Spencer's teachings Professor Morris exclaimed to the students of the Johns Hopkins University, "all this is gratuitous, extra-scientific absurdity, contradiction and dogmatism." Professor Morris does not stand alone in this opinion, and he has at least our hearty endorsement.

It is possible to believe strongly in the theory of evolution and accept every scientific fact that has ever been demonstrated, and yet receive no shock to a belief in a Divine Providence, while the accumulation of scientific facts in our opinion all tend to confirm such belief, and to demonstrate scientifically that an intelligent Creator has designed and pre-arranged the order of both matter and mind.

In conclusion, we desire to say decisively, that science is not answerable for the vagaries of Mr. Herbert Spencer, his editorial supporters, and others of the same class; his atheistical dogmas are neither founded on scientific investigations or in harmony with scientific discoveries. The mere fact that a scientific journal is made use of for proselyting such views even to the extent of attacking editorially, a President of a university who declined to use a recent work of Spencer's as a class-book, should not be considered evidence that scientific men, as a body, have any regard for the extreme views of Herbert Spencer. On the contrary, those engaged in real scientific work, do not care to interfere with their neighbor's religious opinions, much less do they desire to force atheistical views upon them.

Lastly, we say emphatically, that there is no real conflict between Science and Religion at this present day. Some persons appear to consider that they have a mission to stir up discord and contention between scientific men and their best friends, and the worst feelings are engendered by continued attacks against men holding any religious views who form nine-tenths of the population in all civilized countries.

What better evidence can be given for the correctness of the position we take than the fact, that a large number of our most esteemed scientific workers are men in holy orders. We could fill a page by the mere enumeration of their names. Dallinger, the biologist, who has carried off the highest scientific honors, is a Protestant Clergyman. In astronomy we have a Catholic priest who successfully investigates the mysteries of the heavenly bodies, for Secchi's name will always be classed among eminent astronomers. If there was any real conflict between science and religion, would these men have continued their investigations? Of course not. The conflict at this day is wholly imaginary, invented and kept alive for sensational purpose. If these men would cease their irritating interference, science would be welcomed in every home and be considered one of the most convincing evidences of a divine Providence, instead of being hated and dreaded, as not in harmony with any religious belief.

We do not deny that there are many who cling to religious dogmas which have been exploded by facts revealed by science. For such we have compassion, but we hold in far higher contempt the bigoted blustering fanatic who has no religious belief whatever.

Hume admitted that he dared not select his own confidential servant from such as held his own principles. We believe we are correct in saying that Professor Huxley, who holds views somewhat akin to Spencer, is careful in selecting a school for his children where the Bible is taught. These facts appear to show conclusively that these advanced thinkers considered that there was a possibility that they might be wrong, and that some discretion was necessary in teaching their atheistical views, at least in their own families.

We apprehend that similar prudence should be practiced by all who are directly or indirectly answerable for now *popularizing* views and principles which, if successfully propagated, will be destructive even to a simple belief in God, and aim to undermine society itself by denying the intrinsic value of morality.

Finally, we ask that science shall no longer bear the odium of atheism; that it be freed from this pernicious parasite, and that atheism being published in journals devoted to that subject, shall be supported only by its own devotees.

WE trust the above remarks may not be interpreted as an attack on the "*Popular Science Monthly*" as a journal, or personally on the editors. The latter are gentlemen, honored and respected wherever science is known, and have been pioneers in the good work of introducing scientific knowledge into the homes of the people; their journal has always been conducted in a manner to defy criticism, and is an honor to the house which publishes it. The recent editorial was a bold demand for criticism on the policy of the journal teaching doctrines, which appear to lie outside of its province as a scientific journal. To this we have responded.

The root of the question at issue lies in the interpretations of the works of Herbert Spencer. We consider Professor Morris a safe guide in this matter, and a perusal of his letter will show that Spencer's writings have a dual character, they *partly* confirm the position taken by the "*Popular Science Monthly*," so far as showing Spencer believes in a "*something*," but are fatal to all the deductions drawn by the editors of that journal, and strictly in accord with the position we have reluctantly taken in this controversy.

NEW YORK ACADEMY OF SCIENCES.

Dec. 12, 1881.

SECTION OF GEOLOGY.

The President, Dr. J. S. NEWBERRY, in the Chair.

Forty one persons present.

Mr. N. L. BRITTON presented

"ADDITIONAL NOTES ON THE GEOLOGY OF STATEN ISLAND." *

Two wells have recently been sunk to a considerable depth on Staten Island, in the vicinity of Stapleton. One of these is on the property of Mr. J. J. Cisco, near the summit of the Serpentine hills; the section as given by the Superintendent of the Pierce Well-boring Co., who sank it, is as follows:

Glacial drift, ...	50 feet.
Soapstone, ...	150 feet.

* These notes are supplementary to the paper on this subject read by r. Britton on April 4, 1881. (Ann. N. Y. Ac. Sci., II, 161.)

The well is six inches in diameter, and sufficient water was obtained to make it a success.

The other well is at the pump-house of Bischoff's Brewery, some 500 feet east of the most eastern serpentine outcrop at the foot of the hills. This has now (Dec. 1st) reached a total depth of 210 feet, and the boring is still unfinished. The section thus far has been as follows:

Glacial drift.....80 feet.
Various kinds of tough hornblende schist, apparently varying to serpentine,....130 feet.

As yet no gneiss nor granite has been reached.

An outcrop of clay occurs near Clifton, about three-fourths of a mile south of the Forts, near the southern edge of the terminal moraine; it has been found, by borings made by Mr. Charles Townsend, in excavations for cellars, to be at least ten feet in thickness, and of a light color.

The clay is probably of Cretaceous age, and if so, this is the most eastern point at which beds of that age are known on Staten Island.

Mr. W. T. Davis has recently observed a large fossiliferous boulder of Schoharie Grit on the shore at Brighton Point. The fossils have been submitted to Dr. Newberry, and the following species identified:—*Dalmanites anchiops*; *Orthoceras Pelops*, *Strophodonta hemispherica*; *Atrypa reticularis*; *Strophomena rhomboidalis*; a *Fenestella*; and *Zaphrentis prolifera*.

Glacial groovings have recently been noticed on the hornblende-rock, which is exposed at tide-level on Brighton Point. Some of the grooves are at least one-quarter of an inch in depth, three inches wide and four feet long. Their bearing varies from N. 15° W. to N. 17° W.

DISCUSSION.

Prof. D. S. MARTIN considered the specimen of so-called hornblende schist from the well-boring, not to consist properly of that rock, but to be partly hydrated—apparently a less altered condition of the rock which higher up gives us the soft, semi-fibrous serpentine of the island.

Dr. NEWBERRY regarded the serpentine of Staten Island as probably a pseudomorphous condition of hornblende slate. It differs considerably from the mottled serpentine of New York Island, which is "verde antique"; that is, is composed partly of serpentine and partly of carbonate of lime, and is scarcely distinguishable from the Moriah marble, which is quarried at Moriah, Thurman, etc., in the Adirondack region. It is a peculiar rock, and one of the connecting links between the rocks of New York Island and those of northern New York and Canada. Taken together, these afford strong indications of the Laurentian age of the New York Island and Staten Island crystalline rocks.

Dr. Newberry further said that the accurate determination of the age of the rocks of New York Island, of Staten Island, and of those underlying the drift of Long Island, was in the highest degree desirable and important; and while he was satisfied that the former were Laurentian, and the latter Cretaceous, it was eminently desirable that unquestionable proof should be found of this, if it is true. At present no positive assertions could be made, and the duty devolves on the geological members of the Academy to rid the subject of doubt.

The fossils in the boulder referred to by Mr. Britton prove to have come from the Schoharie Grit. In its original condition this was a hard, compact blue limestone, but is here presented in a leached state, by the passage of waters containing carbonic acid, with a loss of its lime, color, and density. It was derived from northern New Jersey, to which locality a belt of this rock runs down from Schoharie county. Its transit by ice was effected without doubt through the valley of the Hackensack, which lies east of the Orange Mountains and west of the Palisades. This glacial movement is indicated by the direction of the striæ observed by Mr. Britton, as well as by those in the Hackensack valley.

Mr. A. A. JULIEN recalled the results of his lithological examination of the serpentines both of Staten Island and of Hoboken, presented before the Academy two years ago, in which it was shown that sections of all these rocks abounded in minute fragments of more or less altered amphibole. The conclusion then stated, that these serpentines must be certainly derived from hornblende schist, was confirmed by the interesting discovery of the latter rock, both in well-boring and on Brighton Point. Serpentines of the same general character and origin occur frequently throughout New York and Westchester counties. The mineral serpentine is also found in small quantity as a vein-deposit, not pseudomorphous, like the main mass, but presenting an amorphous material with banded vein-structure, associated with magnesite, dolomite, etc.; e. g., the marmolite of Staten Island, a translucent green variety found at Hoboken, and also at West 60th street on New York Island, etc. At all these localities the amphibole survives in a more or less altered condition; e. g., the tremolitic talc schists and slaty tremolitic serpentines of Staten Island and Hoboken, the hydrous anthophyllyte and unaltered tremolyte rock of West 60th street, New York, the tremolitic amphibolyte of New Rochelle and Rye, in Westchester county, etc.

Mr. BRITTON confirmed the last remarks, by the statement that a vein of material, strongly resembling the hydrous anthophyllyte of New York, had been struck at the bottom of one of the wells on Staten Island; also that veins of mixed serpentine and calcite were observed at Stapleton, possessing a banded structure parallel to their walls. At that point the apparent thickness of the serpentine bed is 150 feet, but the crest of the hill is composed of talcose schist.

MR. W. LE CONTE STEVENS then read a paper on "THE MAMMOTH CAVE OF KENTUCKY,"

He also exhibited specimens of the blind fish (*Amblyopsis spelaeus*), and blind crawfish (*Cambarus pellucidus*), and stereoscopic views of various points in the interior of the cave.

(Abstract.)

At the close of the Cincinnati meeting of the American Association for the Advancement of Science, in August last, he was one of a party of seventy-five members who visited the Mammoth Cave, remaining there two days, during which the greater part of the time was spent in exploration. He made no claim to new discoveries, but wished to call the attention of the Academy especially to recent observations, for the most part by Rev. H. C. Hovey, of New Haven, in regard to the temperature and structure of the cave. Mr. Hovey read a paper on this subject in Cincinnati, only a brief abstract of which has yet appeared in print, making use of a map, which is the first of its kind ever exhibited. The strictest precautions are observed by the authorities controlling the cave to prevent visitors from taking surveying instruments in with them: but the present manager, Mr. Francis Klett, has made a careful survey of the most interesting parts, and in time this will probably be given to the public, though possibly the scale of measurement may be withheld.

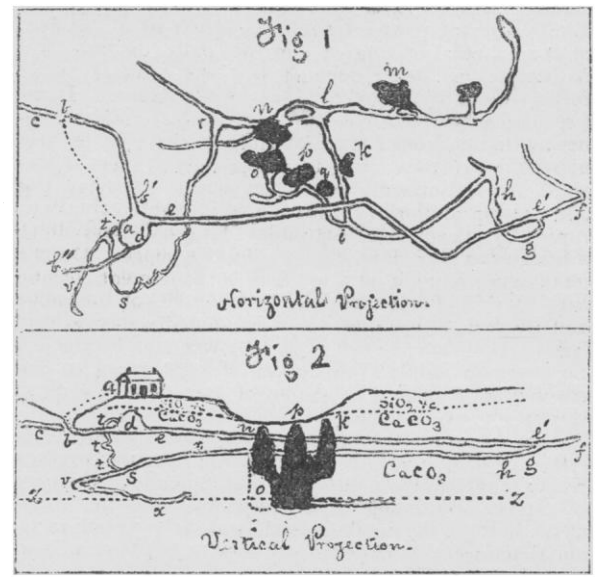
The central and right-hand portions of the map exhibited by Mr. Stevens had been enlarged by him from a copy of Mr. Klett's map. The left-hand portion was drawn only from recollection of the localities traversed, and not to scale, being intended only to illustrate principles. The same remark applies to the vertical projection, the lettering of which corresponds with that of the horizontal projection.

The temperature observations of Mr. Hovey were con-

ducted with much care, and the very best instruments had been confided to him by the Director of the Winchester Observatory at New Haven. In August, 1881, while the external temperature at the neighboring hotel varied between 90° F. and 100° F., at points farther than 100 yards within the cave, the reading of the thermometer was never more than 56° nor less than 52½°, the mean temperature being 54° for the summer months. At a point 1,000 yards within, a thermometer had been left for six months, including the autumn and winter, and daily visited by Mr. Klett, who reported the variation to be only from 54° down to 53°. The underground temperature in this latitude, for points 60 or 70 feet below the surface, is usually assumed to be constant and about the same as the mean annual temperature above. According to Prof. Guyot's maps, the isotherm of 60° passes about thirty miles south of the Mammoth Cave, while that of 50° passes about forty miles north of Cincinnati. The temperature of the Mammoth Cave is fully 6° lower than has been commonly supposed, and may be taken as a fair representation of that of the crust of the earth in the country immediately surrounding it.

Mr. Stevens exhibited a geological map of Kentucky, showing the area of sub-carboniferous limestone in which the Mammoth Cave is situated. This is overlaid with a thin stratum, mostly of sandstone, that is pierced by thousands of sink-holes, through which the surface drainage is carried down into limestone fissures and thus to the general drainage level of the Green River. This stream passes at the distance of less than a mile from the Cave Hotel, the floor of the latter being 312 feet above the water and 118 feet above the mouth of the cave. He briefly explained, with a diagram, the general mode of cave-production in limestone strata, showing that subterranean tunnels must be started by the solvent action of slightly acidulated rain-water, and subsequently enlarged by erosion, along the fissures in the limestone. These agencies are still at work in portions of the cave, and the whole of this limestone country is thus honey-combed with caverns. No tunnel can be thus formed at any point lower than the general drainage level, since there must be an exit for the saturated water. The production of the fissures is referable to the general upheaval of this area at the close of the coal period: but, that there has been subsidence since the completion of much of the Mammoth Cave, is indicated by the fact that at its lowest parts to-day the floor is covered with water to the depth of thirty feet or more, having subterranean connection with Green River. The fissures intersect at various angles, but many of them are nearly or quite coincident with the dip of the strata, which is very gentle. Water passing through these forms the tunnels, while that passing through the vertical fissures scores out the pits which pierce them. The same pit, starting from a sink-hole at the surface, may have successively lower tunnels as exit passages. If the visitor encounters it while walking through the higher, and therefore older, tunnel, the upper part appears to him as a dome, the lower as a pit.

The rate of erosion in the Mammoth Cave has been variable. The older parts are perfectly dry, and entirely free from stalagmitic deposits, indicating rapid erosion, followed by elevation, so as to deviate the water completely into other channels. In the newer parts the water is still dripping from the surface above, and depositing stalactites and stalagmites; but as a whole the cave is by no means remarkable for these formations, being much surpassed in this respect by the neighboring White's Cave, of more recent origin. Those which do occur are moreover deeply colored with iron, which exists in the soil in the form of both oxide and sulphide. In the dry parts, the ceiling of the cave is more or less covered with efflorescent calcic, magnesic and sodic sulphates, which contrast with the iron-stained limestone, giving rise to the beautiful effects that have conferred celebrity on the opening known as the Star Chamber, and the myriad rock flowers of Cleveland's Cabinet.



The structure of the pits and domes was then illustrated with the aid of the accompanying map, by describing a journey through the cave. From the hotel, (*a*, figures 1 and 2,) the visitor walks to its mouth (*b*), by the side of a shallow ravine, terminating in what was formerly a large sink-hole. The door of this fell through, about seventy years ago, producing the present mouth of the cave, and cutting off part of the gallery, now known as Dixon's cave (*c*), which opens out near the Green river, a half mile distant. A walk of 1000 yards brings him to the Great Rotunda (*d*), about 170 feet in diameter and 100 feet high. It is immediately under the hotel, its roof being not more than 40 or 50 feet from the surface. Besides the gallery, called the Narrows (*b'*), by which access has just been obtained, another tunnel from the further side terminates in the Rotunda, to which the name of Audubon's avenue (*b''*) has been given. The large, almost hemispherical opening, seems to have been cut out by the meeting of nearly opposite streams of water, which found exit, probably, through the main cave (*e*). At some distance within Audubon's avenue, a small opening in the floor is found, connecting it with the roof of the Mammoth Dome, a vast cavern 400 feet long, 100 feet wide and 250 feet high. These figures are of course only approximate, but it is believed that they are not exaggerated. Into this cavern the water is still trickling, and stalagmites are forming with sufficient rapidity to have cemented firmly to the floor a lamp dropped in 1812 and found in 1843. Returning to the Rotunda and passing through a half mile or more of the main cave, the visitor reaches, at *e'*, a large fallen slab of limestone to which has been assigned the title of "The Giant's Coffin." This makes the entrance to a side passage (*g*) which leads off to the lowest part of the present cave. The main cave forms an acute angle (*f*) and may be followed for several miles, terminating abruptly in a pile of rocks, where the roof has fallen in the same manner as at the terminus of Dixon's cave. Many of its side passages and avenues are yet unexplored.

Returning and entering the side passage near the Giant's Coffin the visitor passes obliquely beneath the main cave, starting upon what is known distinctively as the Long Route. At an expansion (*h*) are successive deposits of gravel, sand and clay, indicating the downward course of the water which was here partially arrested.

Some distance further on, the passage forks (*i*). Keeping to the right, the dangerous Side Saddle Pit (*k*) is encountered, which measures 65 feet in depth and 20 feet across. It is surmounted by Minerva's Dome, 35 feet high. The pit yawns across the right half of the floor of the tunnel, leaving a narrow path on the left. A short distance beyond (*l*), the tunnel again forks. Keeping to the right as before, Gorin's Dome (*m*) is reached, and may be viewed with the aid of magnesium lights, from a small opening on the side, ten feet above the pathway. The abysm extends 117 feet downward, 100 feet upward and 60 feet across. Leaving this and passing the fork (*l*), the tunnel is completely interrupted by the so-called Bottomless Pit (*n*) across which a bridge has been laid, resting upon a ledge. Despite its ominous name it does not defy measurement, having been found to be 95 feet deep on one side of the ledge and 105 feet on the other. Almost immediately overhead is Shelby's Dome, 60 feet high. Between the Bottomless Pit and Side Saddle Pit are a pair of very large pits, discovered not a year ago by one of the guides, William Garvin, and examined for the first time last August by Mr. Hovey, who gave to them the names Scylla (*p*) and Charybdis (*o*) on account of the narrow, rugged passage which separates them and the great difficulty and danger of access. By timing the fall of pebbles into the water at the bottom, the depth of each was ascertained to be about 200 feet. Charybdis was seen to be directly connected with the Bottomless Pit. Indeed the latter may be regarded as only a part of Charybdis, its depth, 105 feet, being only that of a jutting ledge, or the floor upon which water ceased to fall after being slightly deviated into Charybdis, where the sound of its trickling is still audible. Shelby's Dome is simply the upward continuation of this combined pit. So narrow, moreover, are the ridges separating Scylla from Charybdis on the one side and from the Covered Pit, (*q*), on the other, and so small is the distance to the Side Saddle Pit (*k*), that it seems in the highest degree probable that this group of pits compose merely the upper branches of a single large pit into which they are all united, or at least directly connected before the bottom is reached, and the small relative depth of the Side Saddle Pit is explicable in the same manner as that of the Bottomles Pit. Such an extraordinary group of pits, forming an apparent nucleus of cave drainage, might be expected to have its counterpart in an unusually large depression, or group of sink-holes, at the surface. Impressed with this idea, Mr. Hovey found in the woods, scarcely half a mile from the Hotel, in the known direction of these pits, a depression (*p* Fig. 2.), many acres in extent, and so deep that from its edge he could overlook the tops of the pine trees that rose from the middle.

Leaving this region of pits and domes, the route leads still downward, passing again under the main cave through the narrow tortuous channel known as "Fat Man's Misery" (*s*) where the distance from floor to roof is in many places not more than three feet. Through the floor a winding passage has been worn away, varying in width and depth from one to three feet. This terminates in a chamber which has received the appropriate name of "Great Relief," where the succession of pebbles, gravel, sand and fine clay again records the work of erosion and deposit. This bed is not more than 50 or 60 feet above the drainage level, and from here down to the River Styx, the ground becomes more or less damp. A succession of bodies of water are then encountered, including the tubular Echo River, which is navigated in boats. It is a part of the tunnel which has subsided below the water level, and is in connection with Green River, being filled to within a few feet of the roof in summer, and completely closed in winter when the Green River rises. The column of air between the water and the impervious roof, closed everywhere except at the two ends, which are three-fourths of a mile apart, serves as a resonator for any note within the range of the human voice, and multiple echoes gliding imperceptibly into each other, continue to be returned for many seconds after the voice has been hushed.

Beyond Echo River, the cave may be followed, with continual ascent, through Silliman's Avenue, the Pass of El Ghor and Cleveland's Cabinet, for about five and a half miles. A pile of jagged rocks, 100 feet high, is then surmounted and the wearied climber is confronted with a large cavern, 100 feet wide and 70 feet deep, where three short branches have united in one tunnel. Following the left branch for a few yards, a hall is found, in the floor of which is a pit 175 feet deep. The corresponding dome overhead is scarcely noticeable as such, for the surface of the ground is not more than 30 or 40 feet distant. The end of the Long Route has been reached.

In returning, the passage through Fat Man's Misery is avoided, and nearly two miles of walking are saved by climbing through a very steep, narrow, winding "Corkscrew" pass (*t*, Fig. 2), starting from the neighborhood of Great Relief and terminating at the side of the Great Rotunda. The vertical ascent is about 140 feet. To even stout-hearted mountaineers, if stout-bodied also, this Corkscrew is an intensified Fat Man's Misery, and upon them it rarely fails to leave strong and deep impressions, which may be of more kinds than one.

In regard to the animal life of the Mammoth Cave, conflicting opinions have been expressed by those who have made a special study of this subject. The bats, lizards and rats that have been found cannot be strictly called cave-dwellers, as they are always at points not so far removed from the outer light as to make this inaccessible, The cave crickets and blind crawfish have particularly long antennae and acute powers of hearing. Most of the crawfish are pale in color, some of them almost white; and this feature has been attributed to the continued absence of light. Crawfish, however, with well developed eyes and of dark color have been often found. These are without doubt either wanderers from Green River or the immediate descendants of such; and many generations of cave-dwelling are required to bring about such changes as have caused the application of a specific name, *Cambarus pellucidus*, to the white variety with only rudimentary eyes.

In regard to the blind fish it is a significant fact that the rudimentary eyes of the young are apparently less atrophied than those of the mature fish. Although to these cave dwellers also a specific name, *Amblyopsis spelaeus*, has been given, they are by no means the only fish found amid this stygian darkness. The existence of fish with perfect eyes, apparently prospering where eyes are useless, shows how much less dependent these creatures are than more highly organized vertebrates upon approximate uniformity in external conditions. To those who have already accepted evolution, there is far less difficulty in believing that the colorless blind fish are the modified descendants of dark-colored ancestors with perfect eyes, which have wandered from Green River into Echo River, than in concluding that they have always constituted a separate species, as held by Prof. L. Agassiz, and subsequently contended by Prof. F. W. Putnam.* Nevertheless, Prof. Putnam has shown that the differences between the blind fish (*A. spelaeus*) and their nearest living congeners are much more than in respect to mere color of skin and power of vision. Whether the internal anatomical differences on which he reasonably lays much stress can be proven to be a natural result of the external conditions imposed by cave life, is a question which, if settled at all, must be settled by zoologists alone. Prof. A. S. Packard, Jr., and Prof. E. D. Cope are as pronounced in their opinion that the blind fish have been evolved from fresh-water ancestors possessing good vision, as is Prof. Putnam in the opinion that their ancestry were denizens of salt or brackish water, with which

* The Mammoth Cave and its Inhabitants. By A. S. Packard, Jr., and F. W. Putnam, Salem, Mass., 1879.

he believes that the cave was supplied at a time when this region was a salt or brackish water estuary. Prof. Putnam therefore concludes that the blindness of these fish has been in no respect a consequence of subterranean life.

DISCUSSION.

Mr. BRITTON inquired whether any flora existed in the cave.

Mr. STEVENS replied that, so far as he was aware, no kind of vegetation had ever been found within it.

Dr. NEWBERRY remarked on the geology of the region adjacent to the Mammoth Cave. The limestone beds of this high table-land are jointed in the manner common to rocks, apparently by some sort of polarisation, producing fissures which run in a north and south, and an east and west, direction. The plateau is about 500 feet above the drainage, part of the drainage passing into the Green River, and part into the Ohio. No streams occur on the surface and the drainage is quite gradual. At the angle between these two rivers several streams are seen, bursting out of the cliffs at various heights above the Ohio; they are, so to speak, subterranean sewers, representing the underground drainage of the country; at one point three such streams pouring out of the rock form very beautiful cascades; and near Sandusky a full grown river flows out of the cliff of cavernous limestone. The beds consist of lower carboniferous limestone, with sandy layers beneath. In the vicinity occur portions of the great "blue grass region," one of the oldest parts of the continent, once an extensive highland, forming an island in the sea. Around this, rims of sediments were deposited, consisting of sandstones and limestones; while on the other hand, the continuous process of erosion, during the lapse of a vast period, removed the material of the table-land within, and converted it into a broad depression or basin, the "blue grass region," above which the present plateau of the encircling sediments now rises to a height of 500 feet.

The erosion of the joints in this plateau has resulted in the formation of the pits described by Mr. Stevens, but it is probable that some of these may reach 200 or 300 feet below the Ohio and Green Rivers. There is evidence, from borings in the Delta of the Mississippi, etc., that the Continent was formerly more elevated, standing 500 to 600 feet higher at New Orleans than at present; the drainage was much freer, the Mississippi being a free flowing stream, as well as the Ohio and other tributaries. Borings have been sunk in the present trough of the Ohio river, to a depth of over 100 feet below its present bottom, without reaching the true bottom of the trough, the ancient bed of the river, which is perhaps from 100 to 200 feet further down.

Evidences of the same elevation of the continent were observed in caves on an island in Lake Erie. Long stalactites projected from the roof of a gallery whose end was ordinarily filled with water at the present level of the lake. At times a strong and steady wind has blown down the level of the lake and partially drained this gallery; but even then a guide, John Brown, resident on the island, has swum through the gallery and found the stalactites projecting from the roof as far as he could go.

In regard to the origin of the blind animals, the view of Prof. Cope is probably correct, that they have been derived from the degeneracy of ancestors who once had perfect eyes. No fish is formed with poor eyes; but any organ may be atrophied by disuse, with consequent feeble flow of blood, decreased nutrition, and inevitable shrinking of important parts. An analogy is shown in a comparison of the jaws of prehistoric and modern men. At present our "wisdom teeth" are useless, there is no room for them in the shortened under-jaw; our food being softened by cooking, cut up, and boneless, requires less vigorous mastication; and from disuse, and the consequently insufficient development, these teeth often speedily fall away. In the prehistoric man, on the contrary, the jaws were longer, roomier, supplied with more teeth—the "wisdom teeth" being well developed and kept in strength by constant use on coarse and rough food. The absence of the well-known stimulation produced by light, from the dark waters within the Mammoth Cave, has in the same way resulted in the atrophy of the organs of sight.

CORRESPONDENCE.

The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.]

To the Editor of "SCIENCE."

We can sympathize sincerely with the Editor of *The Popular Science Monthly* in his indignation at being held a promulgator of the views of "pronounced atheists," because of his publication of "the papers of Herbert Spencer, and others of his class." "Pronounced atheism" finds little place in the history of philosophy or science, as in the history of mankind and human civilization in general. And Dr. Youmans is certainly in the right with his emphatic denial that Mr. Herbert Spencer, in particular, pronounces himself an atheist and seeks to persuade others to do likewise. He "and others of his class" have, indeed, been very out-spoken in questioning the literal truth of many popular beliefs and sacred traditions. But that there is in "religious ideas" no "vital element," that they correspond to no fact and represent no truth, Mr. Spencer has been far from asserting. On the contrary, the precise opposite is most strenuously maintained by him (see especially Spencer's *First Principles*, Part I.).

And yet, while all this is verbally true, we fear that Dr. Youmans, in his just zeal to defend himself and his friend, both goes too far in his statement of the latter's real position, and forgets those grounds which lend color of justification to the perfectly sincere supposition of many thoughtful people, that the practical, if not the professed or intended, tendency of Mr. Spencer's philosophy, is in the direction of virtual atheism.

If it were really true that "no man of the present age has reasoned out the foundations of man's belief in the existence of the 'Infinite and Eternal Spirit' with such a depth of analysis and logical force as Herbert Spencer," if, as Dr. Youmans further declares, it were strictly true that Mr. Spencer "has sought to show that the 'Infinite and Eternal Spirit,' of which all the phenomena of the universe are but manifestations, is the most absolute of all realities," then religion would owe to him a debt of gratitude, which it is inconceivable that the intelligent defenders of religion should not gladly recognize and avow. But we are at a loss to know on what grounds the above assertions are made by the Editor of *The Popular Science Monthly*. Perhaps it is in esoteric discoveries, delivered to a select few of his admirers, that Mr. Spencer has "reasoned out" the aforesaid "foundations" and "sought to show" the pre-eminent absoluteness and reality of the 'Infinite and Eternal Spirit,' and Dr. Youmans's statements may have been made on the basis of what he has personally been privileged to hear of these discoveries, Thus the writer of these lines was once informed by an admirer of Mr. Spencer's, who had recently come from a personal interview with the philosopher, that the latter believed in "a God"—*supposing, not without a good deal of reason, that this would be a piece of news to one who knew of Mr. Spencer and his opinions only through his published writings.*

It is in the latter way, only, that Mr. Spencer is known to the general public. We, for our part, cannot claim for ourselves familiarity with every line which Mr. Spencer has ever written. But we have studied with great care and with great interest, what we supposed to be Mr. Spencer's of the redistribution of matter and motion. Some of these phenomena have indeed a *mysterious "obverse"*

most important philosophical works, and we do not remember any where to have noticed any evidence of concern on the author's part to prove the existence of an "Infinite and Eternal Spirit." On the contrary, we are every where forbidden by him to regard the Infinite and Eternal, or the Absolute, as either Spirit or matter. Both of these "antithetical conceptions" are held to be purely finite, relative, phenomenal. The absolute is simply "the unknown reality which underlies both," (see *First Principles*, last sentence of the book, *et passim.*) The absolute we are constantly reminded is "wholly unknowable." It is neither Infinite and Eternal Spirit, nor Infinite and Eternal Matter, but simply an altogether indefinable and incognizable somewhat. "That through which all things exist" is in Mr. Spencer's language, "The Unknowable."

The Unknowable is further held to manifest itself to us only as an "inscrutable force" whose operation is exclusively confined to the evolutionary and mechanical "redistribution of matter and motion." Since this operation takes place under the form of rule or law, it is held to conflict with, and render impossible, the supposed "free will," and hence the truly *spiritual nature* of man.

The case is therefore as follows: That there is an absolute reality, we are held to know through "a dim" or wholly "indefinite consciousness," which is called the "*raw* material of mind," but which utterly refuses to be grasped, defined, or known. The "Infinite Something," which is thus demonstrated for us, is, so far as our definite knowledge extends, and hence practically, an "Infinite Nothing." Strictly known to us are only phenomena aspect, which we term spiritual, ideal, or mental. But no scientific interpretation of these is possible, no knowledge proper is possible concerning them, except so far as they are reducable, directly or proximately, to terms of the redistribution of matter and motion in physiological processes. All our definite knowledge, therefore, is both in its data and its substance, exclusively physical and materialistic, and even the "indefinite consciousness," by which we are held to be assured that an Absolute Something exists, in as regards both its subject and object, also physical; it is certainly not spiritual.

Now, if God, provided he exist, is necessarily a spirit; if man, as the subject of religious emotions and relations, must also be a free spirit; and if, as is the case, there is found in Mr. Spencer's philosophy *no recognition of either God or man as a spirit*, then it is obvious that much ground is given by Mr. Spencer for the supposition that his doctrines—considered *per se*, or independently of their author's intentions—*are virtually atheistic and anti-religious*, and those who honestly entertain this supposition are entitled to be met, not simply with a vigorous *assertion* that they are in error, but with a dispassionate and objective demonstration that they are so.

The whole basis of Mr. Spencer's theory of knowledge is, as is well known, sensational and physical. From such a basis it is and has always been found impossible to rise to the recognition of the absolute as spirit, or man as spirit, or to *comprehend religion otherwise than as a necessary historic incident in the development of ideas*. But the whole basis of human knowledge is not sensational and physical. Free religion implies this, and the grander historic forms of philosophy demonstrate it. The *pre-eminent* intention of knowledge in physical science is indeed sense. The attempt to make this criterion universal leads necessarily to agnosticism with reference to the non-sensible (the Spiritual, Living and Powerful). But it is not *science* which dictates this attempt, and *so Mr. Spencer's agnosticism is not to be charged to science*. The rather, it is due to a purely arbitrary determination on his part, supported, it is true, by the influence of a conspicuous line of predecessors in the history of British speculation. The fact that many theologians have been equally—and some of them—*e. g.*, William of Ockham—even more absurdly agnostic than he, is not to Mr. Spencer's credit, but to the theologians' discredit. Besides, the agnostic theologians have generally made vigorous affirmation, on the authority of the heart, of that which to their heads was inscrutable. They have, like Kant, practically affirmed that which seems theoretically incomprehensible. However, all this belongs to the sadder side of the history of human thought. Philosophy and theology have existed and still exist in larger, more positive, and more fruitful forms, founded on a completer science of knowledge, which recognizes the spiritual factor in knowledge, or the knowing agent, and so, necessarily, the spiritual nature in the absolute object of knowledge or God.

We say, then, that Mr. Spencer is by no means to be charged with intentional atheism or irreligion. To theism and religion he gives all the meaning which it is possible for him to give them on the basis of that physico-scientific theory of knowledge, which he sincerely believes to be the only possible one. But this meaning really falls absolutely short of meeting the actual requirements of theistic doctrine and living religion. And Mr. Spencer's doctrine in this regard is not that of science, whether "popular" or otherwise, but of a highly artificial and arbitrary "philosophy" It has no more necessary relation to the doctrine of evolution than to the doctrine of gravitation, both of which have been and are (in some form) unquestioningly held by many leaders in spiritualistic or positive (*vs.* agnostic) philosophy..

The dissemination of the eminently valuable results of Mr. Spencer's scientific labors is certainly in place in a *Popular Science Monthly*. But with what special propriety such a periodical should also be made the peculiar vehicle for the promulgation of his extra-scientific *philosophy* it is hard to see. It is not that we would have a line, which Mr. Spencer has written, suppressed or kept from the knowledge of the world. But regard for the honor and purity of * science, to mention no other consideration, is enough to make one ardently wish that it should not be constructively put forward as sponsor for doctrines whose basis is only quasi-scientific, and which, in truth, belong to another domain—the domain of philosophical inquiry.—GEORGE S. MORRIS, *Professor of Philosophy, University of Michigan; and Lecturer in the Johns Hopkins University.*

THE HOLLAND HYDROGEN FIRE APPARATUS.

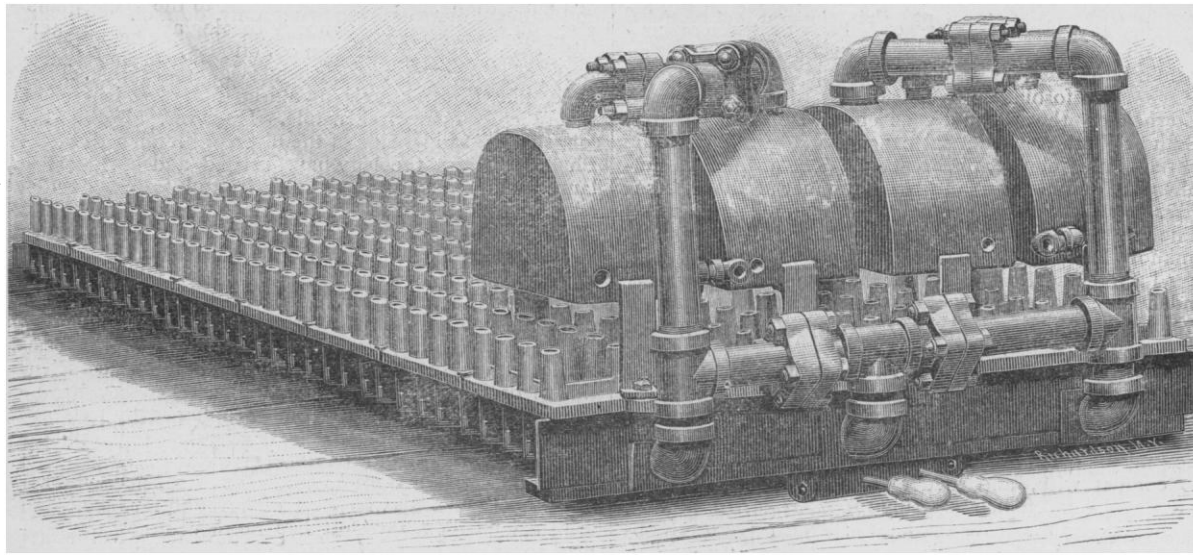
No little interest has been excited during the past year, both in the scientific and practical world, by the remarkable development of results from the Water Gas Apparatus of Dr. Charles Holland, in an ordinary locomotive, as reported by a careful and disinterested observer, through the daily press, and subsequently discussed from a scientific point of view in this journal.

A review of the subject, which has lost none of its importance in the light of further experience and deliberation, will be timely and interesting at the present date.

At Flatbush, the apparatus was placed in the fire-box or furnace of a large (forty-ton) passenger locomotive, of the usual coal-burning pattern, with 16x24 inch cylinders, 5-feet 2-inch driving wheels, and a boiler 23 feet long. In place of the ordinary grate bars are laid three hollow bars or pipes the length of the furnace (8 feet), and from each side of each pipe rise burner-tips at short intervals, making 352 in all. On these pipe-bars, as sleepers, is laid a floor of iron plates studded with open thimbles, through which the 352 burner tips rise to within half an inch of their openings. Over the first 44 burners, next the door, are set four retorts—heavy, hollow blocks of iron—in a row. Two of these retorts receive naphtha, and two water or steam, through separate pipes, and when heated, unite and discharge their vapors through connecting pipes into the pipe bars under the iron floor, and thence through the 352 burners.

The observations at present available enable us merely to compare the firing-up of the same locomotive to the same pressure under substantially equivalent conditions,

* By "science" we mean, in accordance with the now prevalent usage, the mathematico-physical or descriptive science of sensible *phenomena*.



FIRING APPARATUS OF THE NEW HYDROGEN-BURNING LOCOMOTIVE.

first with the Holland Hydrogen Process, and afterwards with coal and wood. This comparison is practically sufficient in a broad sense, yet for more exact purposes it is to be expected that opportunity will soon be taken to obtain the result in pounds of water evaporated per pound of naphtha, and also to exhibit chemically a specimen of the gas. We learn that the boiler of the new hydrogen-burning locomotive, since built at Paterson, after having been tried with very small flue, has proved that the highly expansive and volum nous gas produced requires more room for its most advantageous combustion, and the small flues, are now being exchanged for larger. The production of steam pressure was still more rapid and economical than in the Flatbush experiments, but the heat was so unequally distributed, and the fire so insufficiently vented, through the small flues as to make it evident that they were not adapted to do justice to gaseous fuel as had been expected. For the present, therefore, we are obliged to content ourselves with the latest of the series of tables in which the comparative results of Holland gas and common fuel have been reported.

STEAM, POUNDS.	Time, Minutes.	Naphtha, Gallons.	Naphtha, Per lb. Steam.	Naphtha, per Minute.	Total Naphtha.
10	104	9.9	.99	.054	9.9
20	22	3.21	.32	.146	13.11
30	9½	2.14	.21	.25	15.25
40	8	1.07	.1	.13	16.33
ENGINE MOVES OUT.					
50	10	1.6	.16	.16	17.94
60	5½	1.34	.13	.24	19.27
70	4	1.34	.13	.34	20.61
80	3½	.8	.08	.23	21.41
90	3½	.8	.08	.23	22.22
100	4	1.07	.1	.27	23.29
110	3	.53	.05	.18	23.83
120	3	.53	.05	.18	24.37
SAFETY VALVE BLOWING OFF.					
130	6	1.07	.1	.18	25.44
BOTH VALVES BLOWING OFF.					

This report concludes with a statement of the fuel used in firing up to 120 lbs pressure in the same locomotive, as follows, on June 20: Half a cord of hard wood, cost $3.75; a large quantity of loose pine stuff not measured; and two tons best anthracite steam coal, cost $10; out of which about half a ton was left after reaching the above pressure. Allowing half a ton of half-consumed coal left in the furnace, say one-fourth of a ton in value, the net cost was over $10, against 73 cents for identical work with the Holland gas; 24.37 gallons of naphtha, costing 3 cents per gallon, being consumed. The boiler was specially adapted for coal, but badly encrusted with scale, to the equal disadvantage of both fuels. The difference in direct cost was more than eleven to one in favor of Dr. Holland. The following description of his fire gives some data for an explanation of this surprising, and yet often repeated and verified, result:

The maturer process attained in the experiment of April 29 (and since usual) gave no light visible by day from without the cavern where it was pent, dark and stormy as the cave of Æolus. Raging, roaring, vibrating with a vehemence that shook the iron monster and the ground beneath, and vied with the increasing din of steam from the valves above and under, it was a kind of ghostly noise as well as heat, that to the more habitual organ of perception gave no sign, but seemed causeless or supernatural. In vain we peered through the mica in the door, or peeped and dodged at the small orifice from which a scorching heat spurted fully two feet. Smoke and smell had clean vanished from all parts long before; no unconsumed carbon anywhere escaped to lend the faintest lustre; the carbonic acid formed in the retorts of course came out transparent and inodorous, and so did the hydrogen, with the product of its combustion, the invisible gas called superheated steam; in short, there was nothing of a nature to be seen or smelt in all this *melee* of nature's great elements. Even the illuminating effect of heat upon iron was lost through the expulsive pressure of gases in the retorts, which doubtless projected the flame too far to heat the thimbles that no longer enclosed it, and now stood, like all else, invisible. All ended and came to light again (save the carbonic acid) in a delicate cloud of vapor that rose from the smokestack scalding hot, but too pure to soil white cambric.

To this description it is pertinent to add the following remarkable fact since observed in the trial of the new hydrogen-burning locomotive at the Grant Works, with the small experimental flues referred to as having been afterwards condemned. The fire had been turned down low and the valves set so as to allow the steam gauge to remain stationary at 120 lbs., which it did with perfect steadiness, showing the peculiar controllability of the heat in this process. After about half an hour of this test, the experiment of turning on double water (steam) into the two water retorts was tried, and the valves were set open for this purpose, without restoring the oil feed. The fire was evidently unchecked, and no further notice taken for a few moments, the engineer sitting with his back turned toward the boiler, as the weather was cold; when a violent discharge from the safety valve suddenly caused him to jump nearly to the middle of the tender from the unexpected shock. The steam had run up to 132 lbs., with which the valve was loaded, before a change had been noticed, and so continued blowing off indefinitely, showing a rate of evaporation many times

multiplied by no other change than the addition of more water (steam) from the boiler.

The phenomena and effects of combustion above cited seem to justify the following statement of theory:

The Holland locomotive retorts liberate a pure hydrogen fuel from the mutual decomposition of certain proportions of naptha and steam. The regular temperature of the furnace keeps the retorts hot enough to disengage the oxygen of steam in the presence of the carbon of naptha, the chemical attraction of these two elements causing them to unite in the proportions of full combus ion, and to form carbonic acid within the retorts. The released hydrogen is the only combustible ingredient left to issue at the burners. All the heat of both of these combustions—that of the carbon within the retorts and that of the hydrogen at the burners—is conserved and utilized in the same furnace for the making of steam.

The question now arises on the true causes of the enormous excess of calorific power developed by a given amount of fuel through the water gas process, as compared with the results of direct combustion of the same fuel. Assuming that the amount of carbon entering the retort takes oxygen from the steam with which it mingles, to the proportion of full combustion, and thus liberates just sufficient hydrogen to re-engage the same amount of oxygen; we have first to inquire what proportion exists between the amounts of heat generated by the union of that or any given quantity of oxygen with its proper complements of carbon and of hydrogen respectively. A number of authorities have determined this question experimentally, with results not widely different. According to Grassi, the number of pounds of water raised one degree by the union of one pound of oxygen with its full combining equivalents of carbon and hydrogen, respectively were 2,893 and 4,333. The direct gain by exchange, therefore, would be almost exactly fifty per cent. Numerous experiments by Bunsen and Fyfe are also said to have proved (in indirect accordance with those above referred to) that the fuel (hydrogen) obtained by the decomposition of water, yields a considerable excess of heat above that absorbed in producing the decomposition.

We have made a close scrutiny of the Holland apparatus and its operation for domestic purposes, as exhibited in this city, at the offices of the Heat, Light and Power Company, No. 18 Vesey street. An even pressure of both water and naphtha is secured by an elevated tank for each purpose, at the top of the room. The pipes running from these tanks to the cooking-stove and range are laid in full view, and strict tracing and examination of their course and connections at every point showed that there was no other possible source of supply, of any kind, for the retorts and burners. The oil tank measured 25⅞ inches in diameter, and was computed to hold nearly 2.22 gallons to the inch in depth. In running the cooking-stove, with the oven constantly at a sharp baking heat, the oil was lowered only $\frac{1}{16}$ inch in half an hour, or about one quart (¾ cent) an hour. The whole interior of the store, which had been used a year last May, was free, not only from ashes and soot, but from discoloration, which, obviously, much assisted the effectiveness of the fire, as compared with the coating of non-conducting material accumulated in using crude fuel. It was found impossible to obtain a trace of smoke or odor from the flame upon a white handkerchief; so that, of course, the usual free carbon, hydro-carbon, carbonic oxide, and other gases of crude fuel, could affect neither the atmosphere nor the flavor of food cooked in direct contact with the flame. In the large cooking-range, a third pipe is introduced for the distillation of illuminating gas, simultaneously with the ordinary use of the range. The adjustment and operation excited much admiration. In the progress of the oil through successive coils of this pipe, within the fire box, the several hydrocarbon mixtures it contains are converted, by successive gradations of heat, into a single homogeneous and fixed gas, which resists the most extreme cold of our climate, without condensation, and runs free from sulphurous and other impurities, requiring only dilution with air. After burning a scant $\frac{1}{16}$ inch of oil, the time being taken, the gas-making pipe was opened by simply turning a cock, and in exactly one half the time enough gas was made and measured to amount to 12.55 cubic feet, if diluted to twelve-candle power; when the total oil out was found to be exactly $\frac{3}{32}$ inch, showing a barely perceptible difference from the rate of consumption without making gas, but too fine to measure with the instruments at hand. Roughly allowing it to be $\frac{1}{64}$ for the gasmaking, the cost of the 12.55 feet would be .0347 gal., or about 2¾ gal. per 1,000 feet. This is ¼ gal. in excess of more exact measurement previously taken by gas experts.

But the rough experiment with the locomotive evidences a gain of fully one thousand per cent, from the exchange of carbon for hydrogen, estimating the fuels by cost, in a practical way; although the liquid fuel is of course the dearer of the two, and the gain over the intrinsic value of the exchanged carbon, if it could be ascertained, would therefore be still greater. Fifty per cent from the exchange, then, is at best but five per cent of the total gain, and the remaining 95 per cent must be otherwise accounted for. Nor is there any lack of good reasons for even this enormous difference. In the first place, the carbon is consumed in pure oxygen from steam, no atmospheric air having access to it in the retorts, and therefore the large absorption of heat by the nitrogen of the air that feeds the coal fire, is wholly saved in the water gas process. The consumption is also perfect both of the direct and the produced fuel, against a semi-consumption in the coal furnace. Thirdly, the combustion of the carbon, with all its heat antecedent and consequent, is closely confined in the retorts, from which the heat can escape only by radiation into the boiler, with the exception of the very restricted vent of the hot gases through the burners. Fourthly, the hydrogen obtained issues from the burners at a very high prior temperature, whereas the coal enters the furnace cold. Finally, the hydrogen flame is a vastly more advantageous heating agent than any form of crude fuel, from its unequalled intensity and rapidity of action, and also from its direct contact with the iron, as against the slower processes of radiation and conduction employed by the coal in the furnace. The rapidity with which heat is imparted increases in a geometrical ratio to the increase of it sintensity, and since the hydrogen flame is many times hotter than incandescent carbon, this concentrated heat must have a vastly greater effect, unit for unit, in any given time of passage through the flues. Considering that 90 per cent of direct waste is a moderate allowance in the ordinary firing of a locomotive, it would seem on the whole that we are justified in expecting yet greater economy from this process rather than in theoretically distrusting the results so far reported.

PROGRESS IN MIXED METALLURGY.

By WILLIAM C. CONANT.

Of the fundamental mechanic arts substantially developed before Science or History had a name, Metallurgy was the beginning and the common parent. 'When Adam was yet in middle life, the genius of Tubal-Cain divined and explored the capabilities of the workman's metals, copper, tin, zinc, and iron; fused and mingled them, wrought from them the tools of every craft, and became "the instructor of every artificer in brass and iron." It were hopeless, therefore, to question subsequent records of Time for the era or the occasion of any of the more essential developments in this art of arts. So far as the native surface metals are concerned, it is probable that all the more important metallurgical processes were understood, for substance, long before the flood. Copper and tin, the principal ingredients of bronze, being found comparatively pure at the surface, were naturally the earliest

metals combined and used for mechanical and military purposes. The same precedence of these metals continued, locally at least, and, so far as can be discovered, down to historic times. The Roman historians record it. Weapons, armor, and tools of bronze, hard enough for cutting granite, abound among the remains of primitive antiquity, and have given to that vague epoch the title of the age of bronze: the so-called stone age being of no particular order in time, but rather the universal age of savageism, from the earliest vagrants of the human race down to the recent aborigines, so-called, of our own country.

The disposition to try what will come of mixing materials may be assumed as a prominent native factor of invention in all ages, and as especially prominent in the infancy of knowledge, when every material and every property of materials was a mystery only to be experimented on. Nay, the bare factor of accident would be sufficient to insure the mixture of various metals, ores and earths in the very first experiments. Copper and tin coming out first, as bronze, at once stimulated and assisted an eager search for further discoveries. They built the furnaces and quarried the fuel that ultimately brought to light the treasure concealed in dull brown rocks of iron ore. The more facile ore of zinc (in the presence of copper) if accidentally at hand, would enter earlier, or, possibly, earliest, into the kaleidoscopic series of the smelter's products, with the most exciting brilliancy of effect; promising coveted gold without limit, and preparing, perhaps, the first sad catastrophe of inventive expectation unrecorded in any patent office or prospectus of incorporation. Down almost to the 19th century (1781) brass was made by mixing the zinc ore directly with copper; and down to the 16th century this had been done, from the earliest times, without a suspicion that the magical stone was anything but one out of hundreds of like mysterious minerals, among which a potent and supreme "philosopher's stone" might yet be found. No wonder that infinite possibilities of metallic splendor and preciousness stretched out before the imaginations of the alchemists in the vast field of unexplored mineral combinations before zinc was discovered as a metal and the nature and scope of the alloys were defined.

To these limitations, however, modern philosophy and discovery have given a new and again undefinable extension. They have not revived alchemy, but they have revived a more trustworthy probability, and a more philosophical pursuit of radical improvement in the character of the alloys. In general it may now be stated that the labors of new experimenters with the new lights and resources already promise to popularize little less than the beauty and incorruptibility of the precious metals in the equipage of common life and arts, and in combination with some of the qualities hitherto inseparable from a coarse, dull and corruptible texture, as in iron.

The discovery of nickel and German silver were marked steps in the direction of the new era, yet failed to approximate it; as we see in the fact that nickel has proved hitherto but a material, and German silver a basis, for the temporary and unsatisfactory varnish of beauty called plating. Nickel was found too refractory a metal to be worked solid for purposes of general utility or even of ornament. Qualified by other metals, as in German silver, the same refractory temper still rendered it impracticable, except in proportions too small to impart its clear color and splendor, with its clean, resistant texture and temperature, to the composition formed. Every workable substitute for silver betrayed, more or less, a constitutional sickliness, of jaundiced tint, sweaty feel, and corrupt odor. No actual progress was possible until the discovery that the refractory quality of nickel was due to its absorption, when in a molten state, of certain gases which might be chemically removed. This discovery was made and published in Germany, two or three years ago, with the magnesium method of purifying and reducing the metal to malleability. In practical results, however, we know of little to report as yet from the other side of the Atlantic; whether it be on account of expensiveness in the process, or inability to form alloys of this in itself too expensive metal that are satisfactory at once in cost and in qualities. One suggestion of possibly great importance comes from the German nickel manufacturers, in the comparison of the purified metal with Bessemer steel, with which it is represented to be almost identical in practical properties; raising even a suspicion in some minds whether the two may not be modifications of one metal, or of some protean metallic element, of unconjectured range. The whole range of metals, indeed, would not be more extreme, nor, perhaps, more difficult of practical reconstruction than that of carbon. The speculations and partial successes of Mr. Lockyer in the direction of a theory of unity, or rather of duality, and convertibility, in matter, are here forcibly recalled to mind; suggesting that all its families may be the progeny of two universal parent substances, such as hydrogen and oxygen. What if the truth of Nature, after all, lay, metaphorically, near to the surface and to the mystical vision of the old child-like sages, who saw in the "elements" all-generative powers, as Science finds in one of them (fire) a form, and as represented in the Sun the prime form perhaps, of all organic energy? What if Science should yet discover that the alchemists themselves had a true, if not practicable, end in view? Man's dominion in Nature is too marvellous in its present beginnings, for anything to be incredible as to its future perfection.

On the American side the modern philosopher's stone has beensought of late years, with sanguine ardor. A number of different fortunes of respectable size have been sunk in the melting-caldrons, out of which have arisen a succession of bright apparitions, only to prove intractable for use, or turn the old inevitable sickly cast after brief shining. None of our practical experimenters, so far as I am aware, have struck the true lead, the purification of nickel, with one exception. No other man of our day, probably, has given so many years of metallurgical labor so hard and practical, together with study so profound, to the assimilation of the necessary alloys for gold and silver, to the appearance and properties of those metals, as Mr. Charles Wessell of New York. What our chemists may have accomplished, or seemed to accomplish, with a few ounces of metal in the laboratory, it is of less importance to inquire than would be generally supposed. Such achievements, whatever they might be, would have no necessary value, or even validity, in practice: none possible, indeed, unless there were given with them a practical metal-mixer uniting scientific genius and research with the technical knack and stalwart physical capacity for handling metals by the ton in the furnace, to the purpose for which he intends them. Mr. Wessell, indeed, meets this description; but it would be needless to tell any manufacturer of brass or German silver, that no other known counterpart exists. The men they depend on for this service work solely by blind knack, which they catch and lose alternately in the most unaccountable manner, contributing a material percentage to the market cost of these common compositions by their own inevitable percentage of uncertainty, failure, and destruction of materials.

Charles Wessell, the metallurgist of the Holmes & Wessell Metal Company of New York, came to this city from Rome, in this State, a modest working man, whom the future famous discoverer of a genuine popular rival to the precious metals must make haste to head off, if indeed it be not already too late. It is thirteen years since Mr. Wessell began his metallurgical experiments and inventions, by undertaking successfully to electro-deposit a combination of three metals which most chemists would even now pronounce it impossible to hold together under the battery. A very distinguished chemist to whom the product was submitted, gave this assurance in absolute

terms, before making his analysis. His own analysis confounded him; he frankly certified the three metals found in the deposit; and in his subsequent lectures has referred very pointedly to undiscovered possibilities in the philosophy of metals. Undiscovered—for it is the good fortune of the solitary discoverer that the mediating agent vanishes in his thaumaturgic-metallurgic act into thin air, leaving no clue by which the scientific detective can shadow him as yet. Hence it is impossible for the metal worker, or even the chemist as yet, to recast certain of the Wessell metals; since it is too much to ask of him to give away the "combination" that locks his own hard-earned reward against the rapacity of mankind. Science itself must be content for the present with the accomplished facts shown, and with what their author can afford to disclose of methods and principles. Thus, it has become possible to give the necessary alloy to silver and gold with more suitable ingredients than could be used heretofore; ingredients which but imperceptibly deteriorate either the color or the incorruptibility of the precious metals, and, so far as silver is concerned, effect even a remarkable improvement. Stranger results have followed and are still progressively following, from the same discovery, in building up towards gold and silver from the basis of alloys. All of Mr. Wessell's novel compositions —already sufficient to constitute an era in the history of the art—have their origin and their constant method of development in that stroke of genius; for I know not what else to call it in view of the systematic unfoldings and correlations of it in the hands of the same master. The depositing battery, instead of the crucible, is the instrument by which the practicability and the effect of every combination conceived by him is tested in the first instance. As a consequence, partly of this scientific certainty in method, partly of practiced genius in adjusting heat and other delicate conditions according to bulk, weather, color, radiance, fumes, and the hundred unspoken mysteries of his art, Mr. Wessell's matured mixtures, from common brass and German silver upward, come out uniformly and infallibly what they are intended to be; astonishing to veteran manufacturers of metals who have associated him with them in their affairs, and a fact which I hazard little in opining to be without precedent in mixed metallurgy.

In the course of his novel processes of research, Mr. Wessell discovered, probably first, or at least long before it was promulgated elsewhere, the secret of making nickel pure and malleable, and not only so, but also of keeping it pure and malleable, throughout all combinations, processes and proportions, in which he chooses to introduce it. Magnesium was first or independently tried by him; but discarded for a more practical and economical agency, incidentally discovered in experimenting on qualifying or auxiliary mineral ingredients. The means also by which it turns out that the gases so fatal to nickel are kept out after being once eliminated, were a part of the general precautions of an extremely vigilant and, as it were, sensitive operator, rather than preconceived expedients for that express purpose. The methods and results are no worse, perhaps all the better, that their theory was learned from them, rather than they from the theory. It became a significant observation to Mr. Wessell, that various metals, malleable in the original smelter's ingot, grow unmalleable by remeltings. He reasoned that in the large smelting furnaces, from which the metal is drawn off at the bottom, the most of the mass is secluded from unfriendly influences, whatever these may be, until it is suddenly poured into close moulds and cooled: whereas, in the small open furnace or crucible of the foundry, the metal is poured off from a freely exposed surface; suggesting that to his own closely-covered processes was due the continued freedom of the metal from the refractory temper once extracted.

With the chronic intractability of the superior metal has been removed the hitherto insurmountable obstacle to its introduction in sufficient force to impart its noble qualities to a workable composition. It can now be used in any percentage necessary, and the Wessell process for malleability, unlike the German, is one that adds no extra expense. Its remarkable lustre and beauty of color are now as familiar as those of silver, through extensive use in electro-plating, and are rapidly approaching equal favor in the public taste. What is not so familiar to most minds, is the palpable superiority of nickel, at all points, for fine utensil service, such as we require of spoons, forks, knives, &c., for the table. Color is a matter of taste; but there is no disputing the superior durability of lustre and polish as well as of form, that belongs to the harder metal. It yields only to gold in point of resistance to oxidation and corrosion, and defies the attacks of organic acids, sulphur, &c., that instantly mar the beauty and cleanliness of the best silver. Still less commonly understood is the force of character, so to speak, with which this metal suppresses the meaner colors and weaker susceptibilities of lower metals united with it, by its own noble qualities, even when the odds in quantity are largely against it. To this we already owe solid Wessell-silver table ware, not noticeably inferior in any respect to pure nickel, yet at no greater cost than the perishable sham of plated goods. Manufacturers of the latter may not look with favor on the substitution of goods that would last four generations for goods that must be renewed four times in a generation. But such a revolution as this comes of its own weight and carries all before it. The present vast production of plated ware must in a few years become a mere reminiscence, in all its numerous departments.

To an important class of readers and interests, the bearing of Mr. Wessell's discoveries on the metallurgy of gold and silver will seem most worthy of attention. Alloys are necessary to these metals, both for mechanical and commercial reasons. It is no longer necessary, however, to impair their properties or appearance in making them workable or saleable. All grades of gold treated with the Wessell alloys are of uniform color and lustre with eighteen-karat gold, and require more than usually severe and expert testing to detect any differences whatever, between them. By way of illustration, it may be stated that the alloying compositions themselves do not oxydize perceptibly when exposed to the action of the atmosphere in cooling from the molten state, nor yet in the process of granulation. Manufacturing jewellers pronounce the alloy for gold in all respects equal to eight-karat gold itself, although there is not a particle of gold in it. The alloy for silver is a specially important improvement in the non-tarnishing quality. This may be illustrated by an incident in the experience of a leading manufacturer of sterling silver ware—the celebrated Whiting Manufacturing Company. A quantity of sterling had been made up with Wessell alloy, according to standard, 925-1000ths fine. Of the goods manufactured from this lot, a few were wrapped up with others of the same standard (uniform in all the goods of these manufacturers) but made with the usual copper alloy. After lying some twelve months forgotten and undisturbed, the parcel was met with in taking account of stock and opened. The regularly alloyed metal was found coated with the inevitable black oxide, while the original brilliancy of the Wessell-alloyed metal had barely acquired a warm tint. The writer is indebted for this information to one of the chief managers of the Whiting Manufacturing Company. The alloyed silver, electro-deposited on a spoon by Mr. Wessell, was declared pure by the testing chemist of one of our large plating establishments, who hotly called the metallurgist a fool to his face for insisting that it was or could be otherwise. Being requested to expose the spoon to the action of sulphuretted hydrogen in company with another of chemically pure electro-plate, the chemist was non-plussed by finding that while, of course, the latter was instantly blackened, the

color and brilliancy of the Wessell-alloyed silver remained unaffected. The same peculiarity has been observed by the writer personally in Mr. Wessell's low-priced nickeline metal, which holds a pure and strong lustre throughout indefinite exposure to every test that befalls (and befouls) a silver spoon in domestic use.

"INTEGRAL LUBRICATION."

Integral lubrication is an expression that has been selected to describe the effect of a lubricating element which is itself an *integral part* of the surfaces in contact and relative motion, as distinguished from a foreign or extraneous lubricant introduced between the surfaces, requiring constant renewal, and subject to displacement, consumption, waste, deterioration by heating, &c., and to various other imperfections and inconveniences.

Friction results from the resistance of particles in contact to change of position. Lubrication consists in their non-resistance to change of position, as in fluids. Within themselves, therefore, fluids have the property of integral lubrication. Interposed between solid surfaces, whose fixed particles resist change of position, fluids serve to separate such surfaces by a stratum of non-resistant or mobile particles, and thus supply *extraneous* lubrication.

The idea of establishing the lubricating, non-resistant or mobile element integrally in the bearings themselves, rather than extraneously as a distinct intermediate stratum, was the conception of Dr. Stuart Gwynn, the noted engineer and inventor, of two generations, to whom we owe the Gwynn pump and numerous other long established appliances. This idea is the basis of more than twenty patents, relating to the series of compositions by which it is realized under different conditions, all known under the common designation of METALINE.

The conception of union between the opposite properties of solidity and non-resistance, and of integrity and distinctness, in one metallic body, certainly had the boldness, as its realization showed the power, of a stroke of genius.

The important point to be reached by Dr. Gwynn, after his discovery of the possibility of "Integral Lubrication," to render it of practical value, was to make exact determinations of the effect produced on metals, their alloys, oxides, etc. by enormous pressure when they are put into hardened steel moulds of great strength. These trials extended over several years of time and under pressures from five tons or 666⅔ atmospheres to one hundred tons or 13,333⅓ atmospheres per square inch. In these trials he found, without doubt, the true law of the "*Flow of Solids.*" His determinations were finished in 1860.

This department of physics has, since then, been extensively worked by other scientists, and many of the results arrived at have been published. One of the latest of these contributions is an interesting memoir published in 1881 in the "*Revue Scientifique*," by Mr. W. Spring, a German chemist, from which we abstract as follows:

The substances experimented with were taken in the form of fine powder, and subjected, in a steel mould, to pressures varying from 2000 to 7000 atmospheres per square centimeter. Lead filings under a pressure of 2000 atmospheres were transformed into a solid block which no longer showed the least grain under the microscope, and the density of which was 11.5, while that of ordinary lead is 11.3 only. Under 5000 atmospheres the lead became fluid and ran out through the interstices of the apparatus. Toward 6000 atmospheres, zinc and tin appeared to liquefy. Powders of zinc and bismuth at 5000 to 6000 became solid blocks of a *crystalline* fracture. Powders of soft and of prismatic sulphur were transformed into solid blocks of octahedric sulphur. Red phosphorus appeared to pass into the denser state of black phosphorus. Binoxide of manganese and the sulphides of zinc and lead in powder, *weld* when compressed, and exhibit the appearance, respectively, of natural crystallized pyrosulite, blende, and galena. A number of pulverized salts solidify through pressure and become transparent, thus proving the union of the molecules.

The common property in Metaline and the natural lubricants (fluids) is, of course, mobility or non-resistance to change of position in the particles. This property or effect, results, again, from exceeding minuteness, hardness, roundness and polish of particles; obtained in the artificial instance, by pulverization, attrition, and extreme sifting of metallic particles. It is obvious that the particles of soft or brittle substances, such as flour of wheat or dust of stone, are not capable of the rounding polish and consequent slipperiness (integral lubrication) of metallic particles; nor yet of a kindly interpenetration with the surface particles of solid metal. Hardness, also, or resistance to change of form, coupled with non-resistance to change of position, may be an essential requisite to fluidity; so that possibly the particles of water or oil may be much harder as well as finer than those even of metals. The metals, however, are generally susceptible of a degree of polished and rounded comminution that yields a very slippery product. The fluid-like mobility of small shot is a rough illustration of this condition.

The next stage of the invention is to penetrate and incorporate the solid bearing surfaces with the non-resistant or mobile particles. This is effected by two operations, one the product and complement of the other. The prepared particles are in effect compressed into frequent sockets in the bearing surface, so as in the first place to occupy directly the larger part of its area, and in the second place to allow the outer particles (slightly raised) to attach to the microscopic inequalities of the revolving journal, and so migrate, filling both surfaces with a fine permanent ingredient of particles non-resistant to change of position. The particles are forced in with great power, by running a heavy journal at moderate speed, or a light one at a swift rate, with the cap screwed tight enough to stop the machinery or twist off the journal if oil instead of metaline were the lubricant. Under such incalculable concentration of force, the particles, instead of being worked out from between the surfaces, are held and incorporated, forming new surfaces of a permanent but peculiar character. Thenceforward, the interaction of these surfaces works infinitesimal movement, or mutual yielding to each other in their numberless infinitesimal particles, which nevertheless retain permanent cohesion by the same law that unites the more fixed particles of the solid metal; a state of movement in stability, foreign to our sensible impression from solids, yet quite as conceivable as the universal molecular motion supposed to constitute heat. A mechanical union of metallic substances seems to be realized, as different in effect as in method—and yet perhaps not so different in principle—from the results of cofusion or amalgamation.

There is nothing in experience to indicate abrasion between these surfaces, except from the gradual breaking off of the high points which the microscope reveals on the surface of the most highly polished journal, projecting above the metaline surface. In the course of years of running on heavy bearings, these points (which so rapidly blacken oil where it is used as the lubricant), become dislodged in such quantity as to cover the surfaces with rigid specks looking like emery under the glass. To prevent this, it is found advisable, once in two or three years, according to circumstances, to replug the bushing or box with metaline (again projecting a hair's breadth) so as replace that which is removed. By this means the bearings improve with use and progressively acquire a higher and higher finish, such, as tested by the microscope, that it is impossible to approximate it by any other method of finishing. Running in oil, on the contrary, wears out journals and misshapes boxes. The longest periods for which journals have as yet been run in metaline—say ten years—have developed no heating or wear, if the bushings have been properly cleaned and replugged once in two or three years. A "shakeless fit" can be secured with metaline, which, as before remarked, would render movement impossible with any mere interposed lubricant. Journals in metalined bearings, under the heaviest weight, or at the highest rate of speed (as in spindles and polishing lathes)

and even hot, as in the case of calendering and laundering rolls, or coffee-roasters, run perfectly dry, the year round, without attention, without heating unduly, or being injured by external heat, without perceptible wear or loosening, and with a usual reduction of power required, as compared with companion bearings running with oil under the same conditions. Thus the cost of oil is entirely saved while the cost of power is materially diminished; the usual wear of journals and bearings is practically eliminated, while the fit is so close as to exclude dust and preserve or rather improve their round and polish; the labor of cleaning and oiling, and interruptions and bills for repairing are saved; the greasing of fabrics, goods, buildings and machinery is abolished; and the serious danger of fire from oil and the spontaneous combustion of oily waste is wholly removed.

The authority for these comprehensive statements stands in the form of numerous certificates from prominent manufacturing firms, a few of which it will be only proper to cite in this connection, using their own words. Thus: Messrs. Bagnall & Loud, the Boston manufacturers of pulley-blocks, certify that their planing machine was fitted with metaline bearings four and a half years ago, and is still running on the same at the rate of 5000 revolutions per minute, averaging six or seven hours a day. No oil has been applied, and the shaft shows as handsome a polish as could be desired.—Day, Farrington & Co., hardware manufacturers, Brooklyn, report that their emery grinder, with heavy journals running 1600 revolutions per minute, after three and a quarter years without oil or attention, required new bushings from neglect to replug with metaline, which would have kept them up indefinitely. "The journals are a shakeless fit, and run cooler than another grinder running in oil."—In the machine shops of the New York & Harlem Railroad, a circular saw and a Daniels planer had been running on metaline bearings, 1800 and 2000 revolutions a minute, respectively, for three and four years: no lubricants being used, no care or attention being given them, and no wear perceptible.—The Inman line of Atlantic steamships, have used metaline in their wharf machinery for ten years. Their wharfinger and engineer certify to having used metaline gibs on a forty-horse wharf-engine for five and a half years, without lubrication or perceptible wear: where both gibs and slides running in oil used to cut out and require replacement every few weeks or months.—The Excelsior Brick & Stone Company, Philadelphia, state that the metaline bushings of their loose pulleys—48 inches diameter, 12-inch face, 2⅞-inch bore, friction-clutch, and runing 225 revolutions a minute—are as good after four years as when first put in, and fit the shaft as well, having had no lubrication or attention whatever.—The Washington Steam Laundry, New York, state that they introduced metaline bearings for the heated rolls of their ironing-machines about four years ago; resulting in complete relief from the constant difficulty, disadvantage and expense caused by such machinery running with oil.—A number of the most prominent manufacturing jewellers in New York, give certificates to the same effect with that of Baldwin, Sexton & Peterson, who say that they have used metaline bearings for five years without lubrication, at very high speed on polishing-lathes e'c., the journals running cold and with less power than others running with oil.—The Windsor Hotel, New York, after using metalined gibs for passenger elevators for several years, certifies that they are in good order and save the difficulty of keeping the well-way clean and free from the smell of oil.—One of the most extreme pressures that could be tried was that to which the leading blocks were subjected in hoisting granite and iron for the New York & Brooklyn Bridge, frequently causing a strain of four tons on a sheave. Before introducing metaline, the bushing and hardened steel rollers of a patent sheave would be cut completely out (says Engineer Collingwood) in four or five days. "Since metaline was put in, (over 18 months) we have had no occasion even to take out the pin, nor can we discover any appreciable wear."

We learn from *Iron* (London) the contents of a paper read by A. H. Bateman, Esq., F. C. S., before the British Association of Foremen Engineers and Draughtsmen. Mr. Bateman stated that, in London, there had been running, on metaline bearings, for the best part of a year, various kinds of main and counter shafting from 1½ to 3½ inches diameter, and from 150 to 450 revolutions per minute, loose pulleys as high as 700, and latheheads, 2000 revolutions. Elsewhere in England, there were five-inch shaftings and calendering rolls, under more than ten tons pressure; also, spinning frames, circular saws, planing machines, sewing machines, printing machines, cranks, bicycles, etc., running on the same material, without the use of oil. Works have been established on an ample scale in Dundee, Scotland, for metalining all kinds of machinery.

On the practical importance of this invention it seems unnecessary to enlarge, as every practical mind realizes at once that its value must be as diversified as the uses of machinery, and its desirable applications would form a catalogue too long for reading. A few of the lines of vast extent, in which beginnings or preparations have been made for applying metaline, may be noted with interest. The value of metaline to the millions of sewing machines in use suggests itself forcibly enough, from the repulsiveness of oil to the ladies who use them in contact with their carpets and clothing, and in making up rich and costly or delicate fabrics, which a spot of oil from the machine often ruins. The time taken up in oiling the machine is a burdensome tax on the operator, and the destruction of thousands of machines, through forgetfulness to oil them, is a still larger loss. Moreover, the nearly frictionless running of a metalined sewing machine yields the operator a sense of almost spontaneous motion in the instrument, and a delightful relief to the usual fatigue of propelling it; a strain which has, in fact, resulted in sad consequences to many female constitutions. No less obvious, too, is the value of integral lubrication, from its absolute cleanliness, in all machines for making and dressing fine fabrics of any kind.

Railroad journals running with oil cause daily detentions on every road, and frequent disasters by heating their boxes until the Babbitt or other metal is melted out and the train can be moved no further without great caution, delay and danger. A tragical train wreck resulted in Iowa, but a few days since, from the bursting of a wheel by a hot journal, in consequence of the exhaustion of the oil. Great numbers of men are constantly employed in examining, cleaning and oiling, and the expenditure for oil alone is an enormous amount, as well as that for replacing worn-out bushings and axles. When once a car or locomotive is properly fitted up with metaline bearings, these are all in order for one year at least, without a penny-worth further of material or labor, and without a possibility of danger or detention from hot boxes, want of lubrication, or wearing-out of journals and bushings.

Under the several patents for special applications, such as these and others, the American Metaline Company gives exclusive privilege to proper parties wishing to develop a particular use of metaline as a specialty. Metalined sewing machines are already the property of a New York company under the presidency of Madame Demorest, of fashion and pattern fame. Railway cars and engines are to be metalined by a close corporation of capitalists headed by Wm. Jennings Demorest, Esq., with a capital of $3,000,000. The application to sheaves, pulleyblocks, &c., has been taken up very successfully by Bagnall & Loud, Boston. Samuel S. Webber & Co., Manchester, N. H., have the manufacture of metalined spinning frames, &c., which has been tested thoroughly for years, and is now going into mills with many thousands of spindles. Metaline packings for steam, water and gas joints, pumps, &c., &c., are a specialty of Frank

Baldwin, 33 South street, New York. The Hopkins and Dickinson M'f'g Co,, 76 Reade St., N. Y., and Darlington, N. J., have the exclusive specialty of metalined sliding door sheaves and builders' hardware generally. But these illustrations need not be extended.

THE SUN.

By PROFESSOR C. A. YOUNG.

To the Editor of "SCIENCE."

DEAR SIR,—May I avail myself of the columns of your journal to correct a few serious errors which have come to light in my recent book on the Sun.

P. 16, near bottom.—The interval from the vernal equinox to the autumnal is 186 days, instead of 184, as stated. Of course the remaining part of the year is 179 days, not 181.

P. 44.—The earth would fall to the sun in about two months, not four.

P. 240, 241, and 279.—The candle power of the sun is given just four times too great. The figures printed express the number of candles which, distributed over the surface of an opaque globe, would give the same amount of light the sun does, each flame being considered as a small FLAT radiating surface. But this does not express the true ratio between the sun's light and that of a candle radiating freely in all directions.

P. 271.—In the formula for the number of calories of heat generated by the stoppage of a moving body, the denominator ought to be 8338 instead of 850. The factor g (9.81^m), having been accidentally omitted. In consequence, a few lines below, another 850 becomes 8338 also, and 300 ° becomes about 30°

There are a number of other minor errors, which it is hardly worth while to notice here, though they will be corrected in the second edition. C. A. YOUNG.

To the Editor of "SCIENCE."

A friend of mine who is a reliable observer relates an incident which forcibly illustrates the power of parental affection to overcome fear. The gentleman found a nest of young mice and removed them to the ground near by. The mother mouse made her appearance and carried away one of her young and while she was gone the gentleman took the remaining mice in his hand. When the mouse again appeared and could not find her young she seemed to hesitate a moment and then ran up the gentleman's clothes, took one of the young and carried it away. This was repeated until all the young were removed to a place of safety. J. H. PILLSBURY.

SPRINGFIELD, MASS., *Dec.* 27, '81.

BOOKS RECEIVED.

A TREATISE ON COMPARATIVE EMBRYOLOGY, by FRANCIS M. BALFOUR, LL. D., F. R. S. Vol. II. Macmillan & Co., New York, 1881.

An extended notice of this admirable work will appear later, we now simply announce that Messrs. Macmillan are ready to supply the second volume which completes the work, and we feel sure that every Biologist and Anatomist will avail himself of the mass of information included in Professor Balfour's book, which in competent hands must prove one of the most valuable aids to original work in this direction.

ELEMENTARY LESSONS IN ELECTRICITY AND MAGNETISM, by SILVANUS P. THOMPSON, Professor of Experimental Physics in University College, Bristol. Macmillan & Co., Bond St. New York and London. Price $1.25.

AN ELEMENTARY TREATISE ON ELECTRICITY. By JAMES CLERK MAXWELL, Professor of Experimental Physics in the University of Cambridge, England. Clarendon Press Series, Oxford, 1881. Price $1.90. Imported by Macmillan, Bond Street, New York.

Students, and the many practical men who are now studying Electricity with a view to its application to the manufactures and arts, will find that these two books will exactly meet their requirements, in being comprehensive thoroughly practical and reliable. Those who cannot purchase both works, should commence with that by Professor Thompson, and follow with Professor Maxwell's as being more advanced.

The doctrine of the *Conservation of Electricity*, now growing into shape, but here first enumerated under that name, is thoroughly explained in Professor Thompson's book, and may be studied with profit by all interested in the science of electricity. This theory teaches us that we can neither create nor destroy electricity, though we may alter its distribution. According to this view all our electrical machines and batteries are merely instruments for altering the *distribution* of electricity by running it from one place to another, or for causing electricity, when accumulated or heaped together in one place, to do work in returning to its former level distribution.

IDEALITY IN THE PHYSICAL SCIENCES. By BENJAMIN PEIRCE. Messrs. Little, Brown & Company. Boston.

This work by the late Professor Benjamin Peirce is an admirable illustration of the fact, that a man of individuality and sound judgment may pursue the highest scientific work and still find himself in harmony with the religious sentiments of his fellow man.

A great portion of this work is devoted to a review of past astronomical research, and will be read with interest as a reliable exposition written for those who require scientific work explained in simple language.

PHOTOGRAPHIC EXHIBITION.—The substitution of a film of dried gelatin for the thin layer of wet collodion, which the photographer formerly employed as a vehicle to retain the sensitive salts of silver in a suitable condition on his glass plate, has involved considerable alterations in the mechanical appliances used in photography. For out of doors work, or work away from home, the photographer no longer requires to carry what was practically a portable laboratory. Not having to "develop" his pictures on the spot, he need take with him neither dark tent nor chemicals. On the other hand, he must have some provision by which his store of dry plates can be placed, one after the other, in the camera and properly "exposed" without the risk of the slightest particle of light reaching their sensitive surface, other than the light properly directed upon them by the lens. As he wishes to carry an ample supply of plates with him, and as the glass plates themselves make an appreciable burden in a long walk, it is essential that the apparatus for carrying them should be as light as possible; hence have arisen considerable improvement in the camera and its "slides." Again, the increased sensitiveness of the gelatin films makes it possible to give exposures shorter than can be affected by the hand uncapping and re-capping the lens; hence the invention of numerous "instantaneous shutters," by which exposures of a few hundredths of a second can be given, and pictures of moving objects readily secured. These are but instances of the many novel appliances which recent progress in photographic science has originated, and, besides these, there has been, during recent years, many and important improvements in the application of photography to the production of permanent illustrations for books and newspapers. All these varied applications of the art are to be illustrated by an exhibition of photographic appliances which the Council of the Society of Arts announce will be held during January and February next, in connexion with a course of Cantor lectures to be given before the Society by Capt. Abney. Full particulars of this exhibition are given in the *Journal of the Society of Arts* for last week.